
Chrysosplenium aureobracteatum (Saxifragaceae), a New Species from South Korea

Yong-In Kim and Young-Dong Kim

Department of Life Science, Center for Aging and Health Care, Hallym University,
Chuncheon, Gangwon 200-702, Republic of Korea
rladydds0@hallym.ac.kr; ydkim@hallym.ac.kr

ABSTRACT. *Chrysosplenium aureobracteatum* Y. I. Kim & Y. D. Kim (Saxifragaceae) is described as a new species from Gangwon Province in central Korea. The new taxonomic entity, which was uncovered previously by molecular systematic study, resembles *C. sphaerospermum* Maxim. but is readily distinguishable by its golden bracteal leaves and by the long internodal distances of the distal leaf pairs on sterile branches such that leaf pairs are not clustered. Further, the two species exhibit clear differences in their seed coat morphology, which is considered an important diagnostic character in the genus.

Key words: *Chrysosplenium*, Gangwon, IUCN Red List, Korea, Saxifragaceae, seed morphology.

Chrysosplenium L. (Saxifragaceae) is a genus of perennial herbs, with 60 species distributed throughout temperate regions of the Northern Hemisphere, except for two disjunctive species in Chile (Hara, 1957; Ye & Zhang, 1994; Wakabayashi & Takahashi, 1999; Han et al., 2011). In the Northern Hemisphere, the greatest number of species is present in eastern Asia (Hara, 1957), where the genus is thought to have arisen, with several independent migration events from Asia to the New World (Soltis et al., 2001). The genus has been divided into two sections, *Chrysosplenium* sect. *Oppositifolia* Franch. and *Chrysosplenium* sect. *Alternifolia* Franch. (Franchet, 1890). *Chrysosplenium* has also been classified into 17 series based on multiple characters of the leaf, flower, capsule, and seed morphology (Hara, 1957). Soltis et al. (2001) concluded that Franchet's sections are monophyletic, while most of Hara's series are paraphyletic, with the exception of the two series *Chrysosplenium* ser. *Pilosa* Maxim. and *Chrysosplenium* ser. *Macrostemon* Hara.

Among the six species of *Chrysosplenium* ser. *Pilosa*, *C. pilosum* Maxim. comprises four varieties that represent several taxa that have been formerly recognized at either the species or varietal rank, and there is substantial variability in their morphology (Hara, 1957). Recently, Han et al. (2011) recognized two of the four varieties from *C. pilosum* as the

species *C. sphaerospermum* Maxim. [= *C. pilosum* var. *fulvum* (A. Terracc.) H. Hara] and *C. valdepilosum* (Ohwi) S. H. Kang & J. W. Han [= *C. pilosum* var. *valdepilosum* Ohwi], with strong evidence provided by molecular phylogeny and morphological characteristics.

During the molecular phylogenetic study of *Chrysosplenium* ser. *Pilosa* in Korea, Kim and Kim (2011) found a novel lineage that is closely allied to *C. sphaerospermum*. Members constituting the lineage were found to be distributed in mountainous areas of central Korea, including the northeastern portion of Gyeonggi Province, and the northwestern part of Gangwon Province. Extensive field observation and detailed analysis of floral morphology and stem habit during the flowering and fruiting periods, as well as analysis of seed coat characters revealed by scanning electron microscopy (SEM), suggest that this new lineage merits distinction as a new species.

Chrysosplenium aureobracteatum Y. I. Kim & Y. D. Kim, sp. nov. TYPE: South Korea. Gangwon: along Gwangdeok Valley, Mt. Gwangdeok, Gwangdeok-ri, Sanae-myeon, Hwacheon-gun, N 38°05'49.2", E 127°26'56.1", 632 m, 16 Apr. 2009, KYI-2009013 (holotype, HHU; isotypes, HHU, KB). Figures 1, 2C, D

Diagnosis. The new species is most similar to *Chrysosplenium sphaerospermum* Maxim., but can be distinguished by its golden-yellow bracteal leaves, its distal leaf pairs that are not clustered and are separated by long internodes on sterile branches, and its narrower seeds (ca. 0.56 mm vs. 0.64 mm in *C. sphaerospermum*) that have fewer ridges (ca. 16 vs. ca. 18), smaller tubercles (ca. 10 µm in diam. vs. ca. 15 µm), and few (usually one to 10) papillae to ca. 5 µm long on each tubercle.

Perennial herbs small, tender; roots fibrous; sterile branches well-developed, 2 to 4(5) arising from base of flowering stem, erect until fruiting, growing to equal or greater height than flowering stem at full anthesis, repent after fruiting, branching at axils, densely pilose. Leaves on sterile branch simple, opposite, without stipules; blades to 3 × 3 cm,

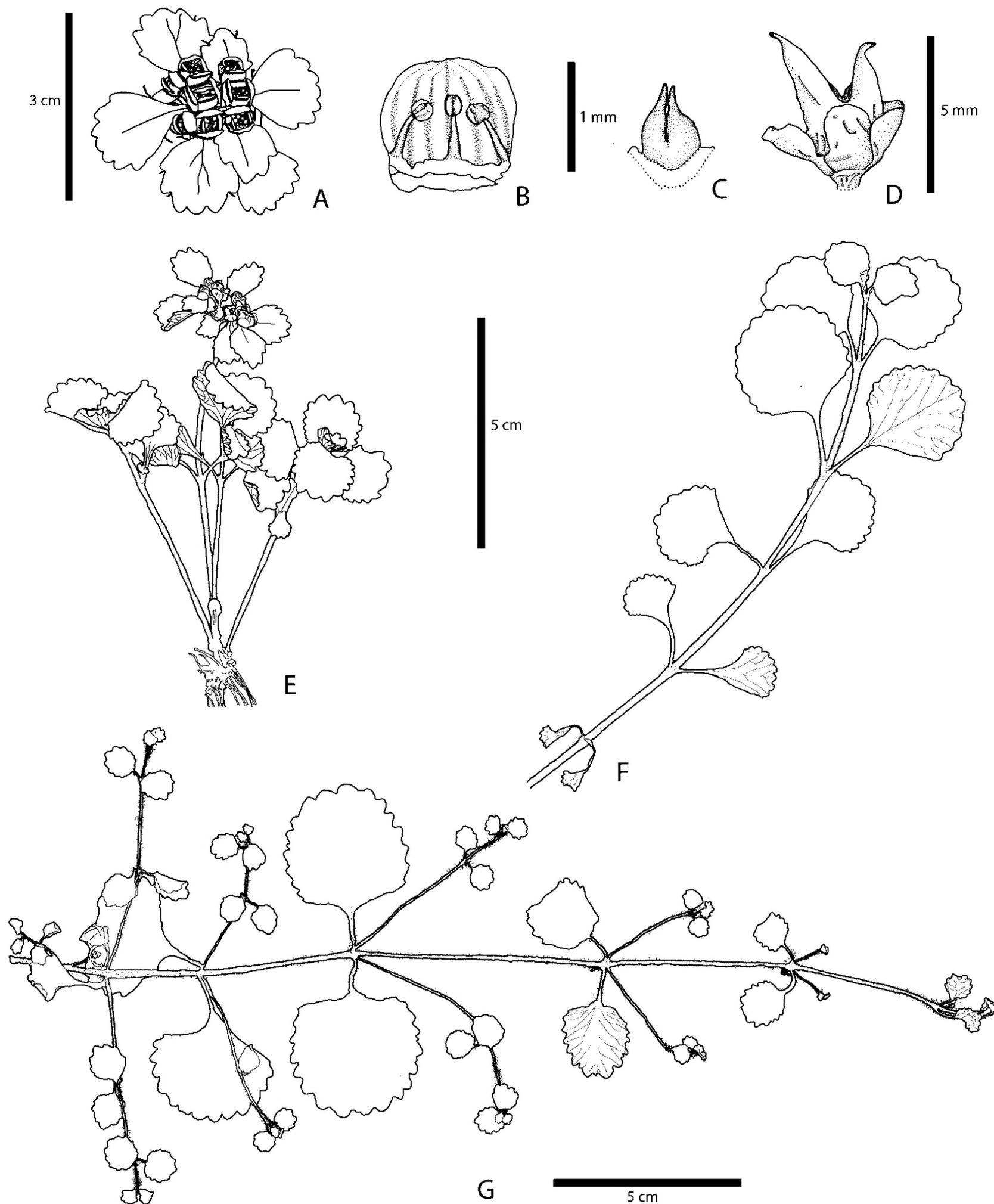


Figure 1. *Chrysosplenium aureobracteatum* Y. I. Kim & Y. D. Kim. —A. Inflorescence. —B. Sepal and stamens. —C. Carpels. —D. Capsule with persistent sepals. —E. Plant habit. —F. Sterile branch habit in fruiting stage. —G. Sterile branch habit after fruiting. A–C drawn from KYI-2009013 (holotype, HHU); D and F drawn from KYI-2009032 (HHU); E drawn from KYI-2012007 (HHU); G drawn from KYI-2013003 (HHU).

suborbicular or widely ovate (upper ones), flabellate (lower ones), apex rounded, base cuneate into petiole, margins crenate with 6 to 20 flat obscure teeth on each side; blades largest in the middle of sterile branches, becoming smaller toward apex and base, distal leaf pairs spaced at long internodal distances;

adaxial leaf surface sparsely pilose, light green, abaxial leaf surface glabrous or pilose on veins, greenish gray; petioles (1–)3–8 mm, pilose. Flowering stems erect, 3.5–14 cm, densely pilose, reddish to purple in lower portion, light green above; leaves on flowering stems in 2 or 3(4) pairs, blades flabelliform,

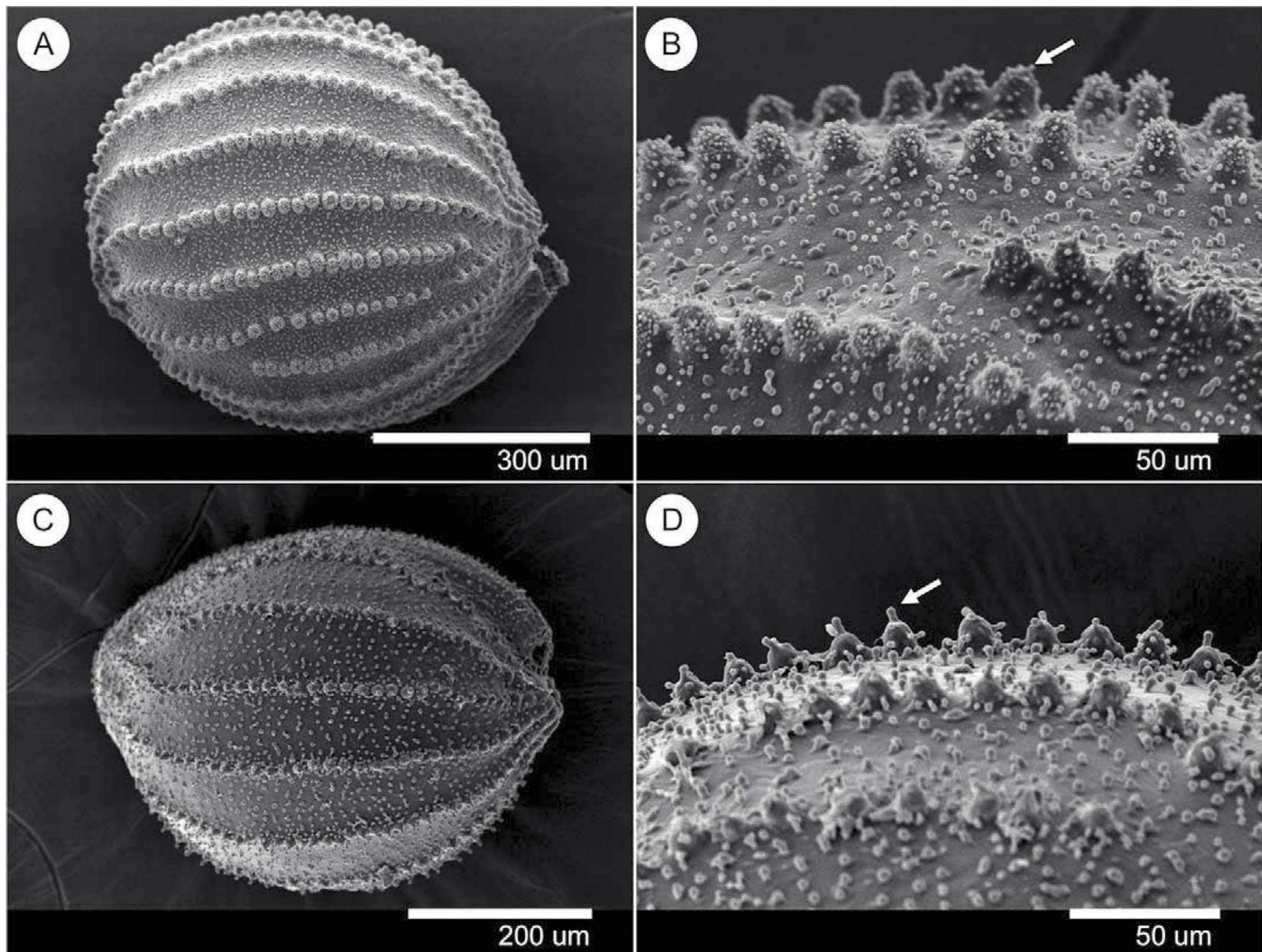


Figure 2. Seeds of *Chrysosplenium sphaerospermum* Maxim. (A, B) and *C. aureobracteatum* Y. I. Kim & Y. D. Kim (C, D). —A. Seed of *C. sphaerospermum*. —B. Close-up of seed surface, revealing ridges with more than 10 deciduous papillae on tubercle (arrow). —C. Seed of *C. aureobracteatum*. —D. Close-up of seed surface, showing ridges of tubercles that are topped by less than 10 deciduous papillae (one indicated at arrow). A and B taken from KYI-2013023 (HHU); C and D taken from KYI-2013029 (HHU).

2–12 × 2–12 mm, both leaf surfaces and margin glabrous, or adaxial leaf surface with sparse clusters of brown pilose trichomes along veins, blade margins obscurely undulate to crenate or distinctly obtusely dentate, with (4)5 to 9 teeth, subtruncate at apex; petioles (1–)3–8 mm, pilose, light green. Inflorescence a 4- to 16-flowered cyme; pedicels sparsely pilose; adaxial bracteal leaves golden-yellow at flowering, turning to light green or yellowish green after fruiting, subflabellate, 5–15 × 5–12 mm, both surfaces glabrous, margins glabrous or sparsely pilose, obscurely undulate to crenate or distinctly obtusely dentate, with 4 to 8 teeth, obtuse to subtruncate at apex; petioles 1–3 mm, sparsely pilose. Flowers with 4 petaloid sepals, one pair overlapping the other in bud, persistent, erect, yellow, widely ovate to widely subelliptic, 1.8–2.2 × ca. 2 mm, obtuse to truncate at apex, slightly recurved at apex; petals absent; stamens eight, 0.6–1 mm, shorter than sepal, filaments filiform, 0.4–0.7 mm; anthers yellow, 2-locular, 0.2–0.4 mm, laterally

dehiscent; ovary semi-inferior, 1-locular, 2-carpelate, with 2 parietal placentae, 0.5–1.4 mm, styles 2, free, ca. 1 mm, stigma punctate, disc absent. Fruit a 2-lobed capsule, ellipsoid, pale green, ca. 5.5 mm, the lobes horn-shaped, slightly unequal, each lobe dehiscent along an adaxial suture; seeds numerous, dark brown, narrow ellipsoid with a carina on one side, thick-walled, 0.6–0.8 × 0.5–0.6 mm, with 12 to 17 longitudinal ridges with prolate hemispheroidal tubercles ca. 10 µm in diam., each with 1 to 10 papillae ca. 5 µm long.

Distribution and habitat. *Chrysosplenium aureobracteatum* is known from Mt. Gwangdeok, Mt. Daeseong, and Mt. Dosol in Gangwon Province and from Mt. Yeonin and Mt. Yoomyeong in Gyeonggi Province in South Korea. The new species has been collected from 630 to 910 m in elevation, occurring in deciduous forests of mountain valleys, where it grows in humid and semi-shady areas near small creeks.

Table 1. Morphological comparison of *Chrysosplenium aureobracteatum* Y. I. Kim & Y. D. Kim and *C. sphaerospermum* Maxim.

Characters	<i>C. aureobracteatum</i>	<i>C. sphaerospermum</i>
Distal leaf pairs on sterile branch after fruiting	distant, with long internodes	clustered, with very short internodes
Bracteal leaf color (adaxial surface)	golden-yellow	green
Seed length (mm)	0.6–0.8	0.6–0.8
Seed width (mm)	0.5–0.6	0.6–0.7
Seed length:width ratios	1.25 (1.12–1.4):1	1.13 (0.94–1.22):1
Number of ridges on a seed	12 to 17	16 to 20
Tubercles on seed ridge diameter (µm)	ca. 10	ca. 15
Tubercles on seed ridge shape	prolate hemispheroidal	hemispheroidal
Papillae on a tubercle number	1 to 10	< 10
Papillae on a tubercle length (µm)	ca. 5	1.5–2.5

IUCN Red List category. *Chrysosplenium aureobracteatum* may be categorized as Endangered (EN) under B1ab (iii) criteria of the IUCN Red List Categories and Criteria (IUCN, 2001). Only five populations are known, with its extent of occurrence (EOO) estimated to be less than 5000 km² in all five populations. Another reason for the endangered assessment is the continuing reduction of its habitat due to expansion of forest roads after its initial discovery on Mt. Gwangdeok, a well-known hiking spot.

Phenology. *Chrysosplenium aureobracteatum* was observed in flower in late March to early May and in fruit in late May to early July.

Etymology. The specific epithet of this new species is taken from the Latin *aureus* and *bractea*, which refers to the distinctive feature of the species having golden-yellow bracts at the time of flowering.

Discussion. Specimens of *Chrysosplenium aureobracteatum* have been previously misidentified as *C. sphaerospermum* [= *C. pilosum* var. *fulvum*], principally because the diagnostic golden-yellow color of the bracteal leaves is ambiguous in dried specimens. Another important diagnostic character, the repent habit of sterile stems after fruiting, is also difficult to discern in dried material, which delayed discovery of this new species. This rather cryptic species is supported by recent molecular systematic analyses that utilized multiple accessions from several populations of the taxa examined (Kim & Kim, 2011). Within the ITS tree, the nine accessions representing the new species formed a distinct clade with a high bootstrap value (99%) and posterior probability (1.0), supporting their divergence from the sister taxon *C. sphaerospermum*. This new taxonomic entity could have been described as a new variety of *C. pilosum*, but recent phylogenetic study revealed the species *C. pilosum* recognized by Hara (1957) to be a para-

phyletic taxon (Han et al., 2011), implying that the recognition of additional varieties within *C. pilosum* would be taxonomically inappropriate. This leads us to propose the new taxon at the rank of species rather than as a variety within *C. pilosum*.

It should be emphasized that not only phenological characters and molecular data support the new species; the seed morphology also distinguishes *Chrysosplenium aureobracteatum* from closely allied taxa (Table 1, Fig. 2). The seed shape of *C. aureobracteatum* is a narrow ellipsoid with lower furrows (i.e., lower ridged) compared to that of *C. sphaerospermum*. The number of papillae on each tubercle are fewer, only one to 10 in *C. aureobracteatum*, whereas this number exceeds 10 in *C. sphaerospermum* (Fig. 2). Since the seed morphology has been considered useful and important for delimiting the taxa of *Chrysosplenium* (Hara, 1957; Han et al., 2011), these distinctive seed characters support the recognition of *C. aureobracteatum* from its closely allied taxon.

Paratypes. SOUTH KOREA. **Gangwon:** Mt. Gwangdeok, Gwangdeok-ri, Sanae-myeon, Hwacheon-gun, N 38°06'24.1", E 127°26'45.7", 732 m, 27 Apr. 2009, KYI-2009022 (HHU), N 38°06'10.7", E 127°26'45.0", 663 m, 25 May 2009, KYI-20090025 (HHU), N 38°06'17.8", E 127°26'36.1", 637 m, 25 May 2009, KYI-2009026 (HHU), KYI-2009027 (HHU), KYI-2009028 (HHU), KYI-2009032 (HHU), KYI-2009033 (MO); Mt. Daeseong, Bong-o-ri, Sangseo-myeon, Hwacheon-gun, N 38°12'24.0", E 127°31'35.8", 704 m, 2 May 2008, Youngdong Kim 2008-0062 (HHU); Mt. Dosol, Haean-myeon, Yanggu-gun, N 38°15'00.5", E 128°06'09.6", 858 m, 4 May 2012, KYI-20120001 (HHU), KYI-2012002 (HHU), KYI-2012007 (HHU), KYI-2012012 (MO). **Gyeonggi:** Mt. Yeonin, Seungan-ri, Gapyeong-eup, Gapyeong-gun, N 37°53'04.5", E 127°24'22.2", 701 m, 14 May 2010, KYI-2010001 (HHU), KYI-2010002 (HHU).

Acknowledgments. This research was supported by a grant from the National Research Foundation of Korea (2012R1A1A2044225) and the Hallym University Research Fund (HRF-201211-012).

Literature Cited

- Franchet, A. R. 1890. Monographie du genre *Chrysosplenium* Tournefort. *Nouv. Arch. Mus. Hist. Nat.*, sér. 3, 2: 87–114.
- Han, J. W., S. G. Yang, H. J. Kim, C. G. Jang, J. M. Park & S. H. Kang. 2011. Phylogenetic study of Korean *Chrysosplenium* based on nrDNA ITS sequences. *Korean J. Pl. Resources* 24: 358–369.
- Hara, H. 1957. Synopsis of genus *Chrysosplenium* L. *J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot.* 7: 1–90.
- IUCN. 2001. IUCN Red List Categories and Criteria, Version 3.1. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland, and Cambridge, United Kingdom.
- Kim, Y. I. & Y. D. Kim. 2011. Molecular systematic study of *Chrysosplenium* series *Pilosa* (Saxifragaceae) in Korea. *J. Pl. Biol.* 54: 396–401.
- Soltis, D. E., M. T. Nakazawa, Q. Y. Xiang, S. Kawano, J. Murata, M. Wakabayashi & C. H. Jetter. 2001. Phylogenetic relationships and evolution in *Chrysosplenium* (Saxifragaceae) based on *matK* sequence data. *Amer. J. Bot.* 88: 883–893.
- Wakabayashi, M. & H. Takahashi. 1999. A new species of *Chrysosplenium* (Saxifragaceae) from central Honshu, Japan. *Acta Phytotax. Geobot.* 50: 1–12.
- Ye, H. & G. Zhang. 1994. A new species of *Chrysosplenium* from Guangxi. *Acta Bot. Austro Sin.* 9: 57–59.